

**IN THE SPECIFICATION:**

*Please replace the paragraph noted below for the paragraphs previously presented. Changes are shown with underlining for additions and strike-outs for deletions.*

*Please replace the paragraph on Page 1, Line 11 under the heading "Cross Reference to Related Application" and before the heading "Background of the Invention", with the following new paragraph:*

This application is a continuation of patent application Serial No. 09/507,539 filed on February 18, 2000, now U.S. Patent No. 6,707,443, which is a continuation-in-part of co-pending parent patent applications:

Application no. 09/103,281, now U.S. Patent No. 6,088,019, filed June 23, 1998 on behalf of Louis Rosenberg, entitled, "Low Cost Force Feedback Device with Actuator for Non-Primary Axis,"

Application no. 09/253,132, filed February 18, 1999 on behalf of Louis Rosenberg, entitled, "Low Cost Force Feedback Pointing Device,"

Application no. 09/456,887, now U.S. Patent No. 6,211,861, filed December 7, 1999, on behalf of Louis Rosenberg, entitled, "Tactile Mouse Device," all assigned to the assignee of this present application, and all of which are incorporated by reference herein in their entirety.

*Please replace the existing paragraph starting on Page 12, Line 19 with the following new paragraph.*

Alternatively, directed inertial forces can be output along the X and Y axes in the planar workspace of the device and can be compensated for to prevent or reduce interference with the user's control of the device. One method to compensate is to actively filter imparted jitter in that workspace, as disclosed in U.S. Patent No. 6,020,876 ~~a pending patent application no. 08/839,249~~, incorporated herein by reference; however, this implementation may add complexity and cost to the device 12. One problem in the present invention for outputting forces in the X and Y directions is that the housing 13 is typically made stiff in those directions, such that forces

will not be easily felt. For example, the rubber feet 60 can be made compliant in the z-direction, but such compliance does not greatly help to magnify forces output in the X- and/or Y-axes. The rubber feet 60 are typically stiff in the x-y plane to prevent the housing 13 from wobbling when the user uses the device 12.

*Please replace the existing paragraph starting on Page 13, Line 12 with the following new paragraph:*

Actuator assembly 80 includes a grounded flexure 68 and an actuator 66 coupled to the flexure 68. The flexure 68 is preferably a single, unitary piece made of a material such as polypropylene plastic ("living hinge" material) or other flexible material. This type of material is durable and allows flexibility of the flex joints (hinges) in the flexure when one of the dimensions of the joint is made small, but is also rigid in the other dimensions, allowing structural integrity as well as flexibility depending on thickness. Some embodiments of flexures used in force feedback devices are described in Patent 5,805,140 and patent application nos. 09/376,649 and 60/172,953 ~~60/\_\_\_\_\_~~, entitled "Haptic Interface Device Providing Linear Tactile Sensations Using A Rotary Actuator," filed 12/21/99, all incorporated herein by reference. Flexure 68 can be grounded to the housing 13, for example, at portion 81.

*Please replace the existing paragraph starting on Page 16, Line 6 with the following paragraph:*

Of course, in other embodiments, the actuator need not be used as the inertial mass. For example, copending provisional application no. 60/172,953 ~~60/\_\_\_\_\_~~, entitled "Haptic Interface Device Providing Linear Tactile Sensations Using A Rotary Actuator," filed 12/21/99, and incorporated herein by reference, discloses an actuator coupled to a flexure that provides a centering spring bias to a separate inertial mass coupled to the flexure, or an inertial mass that is incorporated as part of the flexure.

*Please replace the existing paragraph starting on Page 16, Line 28 with the following paragraph:*

The approximate linear motion of the actuator's moving portion 148 can be used to drive the cover portion 150. Linear forces from the actuator 18 move the link member 150 and in turn move the cover portion 152 ~~150~~ approximately along the Z-axis. Although the cover portion 152 ~~150~~ actually rotates about the hinge in the embodiment of Fig. 4, the range of motion is preferably small enough to approximate linear motion. Preferably, the cover portion 152 ~~150~~ has an origin position (rest position) in the middle of its range of motion so that the actuator 18 can move it both up and down. Also, a centering spring bias is preferably provided to move the cover portion to the origin position when no force is applied by the actuator (and by the user). These embodiments are is described in greater detail in U.S. Patent No. 6,088,019 ~~copending patent application no. 09/103,281~~, incorporated herein by reference.

*Please replace the existing paragraph starting on Page 17, Line 4 with the following paragraph:*

In other embodiments, different moving elements can be actuated to provide contact forces. For example, a button 16 can be coupled to a link member 150 or more directly to a moving portion of actuator 18. The button 16 can be moved in its degree of freedom by the actuator to provide contact forces to a user who is contacting the button. As with the cover portion 152 ~~150~~, the button is preferably centered in its range of motion by a centering spring bias provided by a physical spring or compliance in the button. This embodiment is described in greater detail in copending patent application no. 09/253,132, incorporated herein by reference.

*Please replace the existing paragraph starting on Page 17, Line 11 with the following paragraph:*

Like the trackball device providing inertial forces, the actuator system providing contact forces can be tuned to amplify output forces. Feet 60 can be made compliant ~~compliance~~, and

compliance can also be used in the actuator's moving member 148, the link member 150, and the moving element itself, where appropriate.

*Please replace the existing paragraph starting on Page 17, Line 15 with the following paragraph:*

Of course, both the inertial forces described with reference to Figs. 2 and 3 as well as the contact forces of Fig. 4 can be included in a single embodiment. For example, the link member 150 and moving element (cover portion, button, or other moving member) can be coupled to the moving inertial mass. Such an embodiment advantageously provides inertial forces that can always be felt by the user, regardless of how the housing is contacted, as well as contact forces which can be compelling in particular situations.

*Please replace the existing paragraph starting on Page 21, Line 21 with the following paragraph:*

The actuator described herein has the ability to apply short duration force sensation on the housing of the device (and/or on the user's hand). This short duration force sensation is described herein as a "pulse." Ideally the "pulse" is directed substantially along a Z axis orthogonal to the X-Y plane of the support surface 22. In progressively more advanced embodiments, the magnitude of the "pulse" can be controlled; the sense of the "pulse" can be controlled, either positive or negative biased; a "periodic force sensation" can be applied on the housing, where the periodic sensation can have a magnitude and a frequency, e.g. a sine wave; the periodic sensation can be selectable among a sine wave, square wave, saw-toothed-up wave, saw-toothed-down wave, and triangle wave; an envelope can be applied to the period signal, allowing for variation in magnitude over time; and the resulting force signal can be "impulse wave shaped" as described in U.S. Patent No. 5,959,613. There are two ways the period sensations can be communicated from the host to the device. The wave forms can be "streamed" as described in U.S. Patent 5,959,613 and pending provisional patent application 60/160,401, both incorporated herein by reference. Or the waveforms can be conveyed through high level

commands that include parameters such as magnitude, frequency, and duration, as described in U.S. Patent 5,734,373.

*Please replace the existing paragraph starting on Page 22, Line 6 with the following paragraph:*

In yet other embodiments, an actuator can be provided to output the tactile feedback (such as pulses and vibrations) to the sphere 15 itself instead of or in addition to the tactile feedback applied to the housing 13. For example, a linear or rotary actuator can output pulses on the sphere 15 by vibrating a cylindrical roller in contact with the sphere. Or, a moving portion of an actuator can directly impact the sphere. However, such tactile sensations on the sphere may cause inaccurate cursor control or input for the user, which is generally undesirable. A selective disturbance filter, as described in U.S. Patent No. 6,020,876 ~~co-pending application 08/839,249~~, can be used to filter out the force disturbances on the cursor control. However, in some embodiments this may not be adequate since vibrations on the sphere are difficult to sense with accuracy and therefore difficult to filter. Other embodiments may provide accurate enough sensors, such as multiple emitter/detector pairs sensing small motions of the sphere, which can allow for adequate disturbance filtering.

*Please replace the existing paragraph starting on Page 22, Line 18 with the following paragraph:*

Actuator interface 216 can be optionally connected between actuator 18 and microprocessor 210 ~~110~~ to convert signals from microprocessor 210 into signals appropriate to drive actuator 18. Interface 216 ~~28~~ can include power amplifiers, switches, digital to analog controllers (DACs), analog to digital controllers (ADCs), and other components, as is well known to those skilled in the art.

*Please replace the existing paragraph starting on Page 25, Line 8 with the following paragraph:*

Pulse sensations can also be output based on interaction between cursor 246 and a window. For example, a pulse can be output when the cursor is moved over a border of a window 250 or 252 to signal the user of the location of the cursor. When the cursor 246 is moved within the window's borders, a texture force sensation can be output. The texture can be a series of bumps that are spatially arranged within the area of the window in a predefined pattern; when the cursor moves over a designated bump area, a pulse sensation is output when the cursor moves over designated pulse points or lines. A pulse can also be output when the cursor is moved over a selectable object, such as a link 262 ~~254~~ in a displayed web page or an icon 256. A vibration can also be output to signify a graphical object which the cursor is currently positioned over. Furthermore, features of a document displaying in window 250 or 252 can also be associated with force sensations.

*Please replace the existing paragraph starting on Page 25, Line 12 with the following paragraph:*

In another interaction, when the cursor is moved over an icon 256, folder, hyperlink 262, or other graphical target, a pulse sensation is applied. The sensation associated with some elements can be stronger than others to indicate importance or just to differentiate different elements. For example, icons can be associated with stronger pulses than folders, where the folders can be associated with stronger pulses than tool bar items. Also, the strength of a pulse can be associated with the displayed size of the graphical element, where a large tool bar icon can be associated a stronger pulse than a small tool bar icon. On web pages this is particularly interesting, where small graphical targets can be associated with weaker pulses than large graphical targets. Also, on web pages check boxes and hyperlinks can feel different than buttons or graphical elements based on pulse strength. The magnitude of the pulses can also depend on other characteristics of graphical objects, such as an active window as distinguished from a background window, file folder icons of different priorities designated by the user, icons for

games as distinguished from icons for business applications, different menu items in a drop-down menu, etc. Methods of adding tactile sensations to web pages is described in U.S. Patent No. 5,956,484 and 6,219,032 ~~co-pending patent application no. 08/571,606~~, both incorporated herein by reference.

*Please replace the existing paragraph starting on Page 27, Line 24 with the following paragraph:*

On web pages, pulse or vibration content can be used to enhance the user experience, e.g. for web objects such as web page links, entry text boxes, graphical buttons, and images. Methods of adding such content are described in U.S. Patent No. 5,956,484 and 6,219,032 ~~co-pending patent application no. 08/571,606~~, both incorporated herein by reference.